

Dyes, Fibers, and Paper: A Botany Lab Exercise For Non-Biology Majors

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Abstract: This laboratory exercise affords students a hands-on experience learning about traditional dyes, fiber strength, and paper making. It is economical, simple to prepare, provides satisfactory results, and is student friendly. Dyes were extracted from plant leaves, stems, roots, and fruits. Hard-boiled eggs were placed in the dyes for 15 minutes to determine what color each dye would produce. Colors of the eggs differed from the colors of the dye solutions. Fibers were procured from different materials (cotton, jute, hemp, etc.). Filaments were removed from the twine and a stress test was used to determine the strength:weight for each fiber type. Twine from each fiber type was used to make rope using the rope maker from the Boy Scout's Pioneering merit badge pamphlet (1993). Paper was made from recycled fibers suspended in water. A homemade deckle was used to collect and press the fibers to make a sheet of paper. Students found the exercise interesting and stimulating.

Keywords: Dyes, fibers, non-majors, papermaking, rope making, textiles

INTRODUCTION

Most colleges and universities require non-science students to take a science class to fulfill graduation requirements. Often these students take a science class that is specifically designed for non-science majors. This laboratory exercise was designed as part of a plant biology course for this type of student. The course covers the major plant groups, plant structures and functions, and human uses of plants. The theme of the lab exercise is the investigation of how textiles and paper can be made and processed. The exercise is separated into three sections. The first section describes the production of plant dyes and the dying procedure; the second section describes how to make rope and test the strength of the utilized twine; and the third section describes how to make paper. To perform all three activities requires approximately two hours.

All materials for this exercise can be purchased in local hardware stores and supermarkets. Instructors do not need a detailed knowledge-base for each topic to

ensure a quality exercise for the students. A rope maker can be purchased or constructed with a table saw (Boy Scouts, 1993). Materials and equipment for the exercise are relatively inexpensive and many are reusable.

METHODS AND MATERIALS

Dyes

Fresh or preserved plant materials, including roots, stems, leaves, fruits, and flowers, can be boiled in water to produce a variety of natural dyes. These dyes can then be used to color hardboiled eggs, skeins of wool, or pieces of cloth. Dying cloth is a more complicated and time-consuming procedure; therefore, eggs were used in this lab to simplify and expedite the dying process. Required materials for the egg dying procedure include the following: a hotplate or stove, oven mitts, slotted spoons, sauce pans, eggs, egg stands, crayons, paper towels, dye plants (see Table 1), a food strainer, knife, and cheesecloth.

Table 1. The following easily obtainable plant sources may be used to make plant-based dyes for staining eggs or cloth.

COLOR	DYE MATERIALS USED
Blue	Canned blueberries or red cabbage leaves
Brown	One cup hot water plus 1 tablespoon instant coffee and 1/2 teaspoon vinegar
Green	Liquid chlorophyll (purchased at a pet store or drug store.), spinach leaves, or yellow delicious apple peels
Lavender	Grape juice or violet blue dye (see below) plus 2 teaspoons lemon juice
Orange	Yellow onion skins
Pink	Cranberries or beet root
Red-brown	Red onion skins
Violet blue	Violet flowers
Yellow	Orange or lemon peels, carrot tops, celery seed, or one cup hot water plus 1 1/2 teaspoons turmeric or ground cumin and 1/2 teaspoon vinegar

To extract the colors from the plant material, chop or mash the plant tissue into small pieces and place into a 1000 ml beaker and loosely pack the material. Add enough water to bring the beaker contents up to 750 mls. Boil the dye plants until the water turns the desired color, allow the dye to cool, and then filter the dye through a piece of cheesecloth placed in a food strainer to remove any plant pieces. For light dyes, only 15-30 minutes of boiling is required; for darker dyes 1-2 hours may be necessary. Plants can also be allowed to steep overnight. The less water used to extract the dye from the plant dye source, the darker the resulting dye (Casselman, 1980; Kramer, 1972; Thomas, 1980). Dyes can be made ahead of time and stored in the refrigerator or freezer. Place eggs in dye for approximately 10 minutes depending on the shade desired.

Hard boil eggs and allow them to cool. Hardboiled eggs are used to avoid messy breakage of raw eggs. Eggs can be decorated with white or colored wax crayons before dyeing or between dyes if eggs are placed in more than one color. The dye will not stain the area colored with the crayon. Place an egg gently into a container of room temperature plant dye (use a large slotted spoon to lower the egg into the dye). Let the egg sit in the dye for at least 15 minutes. When the egg is ready, use a slotted spoon to remove it from the dye, blot it dry with a paper towel, and place it in a stand to finish drying. The caps from plastic soda bottles can be used as individual egg stands. Alternately, the egg may be placed in a second dye before drying. It is best to first dye the egg with a light dye, then with a darker dye. The longer the egg (or

piece of cloth) is left in the dye, the darker the color produced. Eggs or cloth may also be boiled in the dye for 1-2 hours in order to produce a darker color. Since the eggs may have been sitting out for a period of time before the dying process is complete, **do not eat the eggs**.

Fibers

Required materials for rope making and the string stress test include the following materials: a rope maker or materials for constructing one (plywood, medium gauge metal rods, band saw), balls of string made from assorted fibers (cotton, jute, hemp, etc.), scissors, a balance, a meter stick, 2 ring stands with a crossbar, a weight hook (to hang from the string and put weights on), 1 kg weights, newspaper (to cushion the weights that fall), and a C-clamp (to hold down the rope maker to a tabletop).

Follow directions as per the *Pioneering* merit badge pamphlet to assemble a rope making device (Boy Scout Merit Badge Pamphlet Series, 1993). Merit badge pamphlets are available for \$US 3.15 from www.scouting.org. Three pieces of string are tied to the rope maker and the handle is turned, causing the string to twist together to make a rope. At least three people are needed to make rope using the device, and getting the proper tension on the string requires a little practice.

To test the strength of the fibers used to make the rope above, first cut a 3 foot (1 m) piece of string. Use a balance to weigh the string in grams. Tie one end of the string to the middle of a crossbar clamped across the tops of two ring stands and one end to a weight

hook. Place padding below the weight hook to cushion the weights that fall when the string breaks. Slowly add weights to the weight hook, increasing the weight by 1 kg increments. After the string breaks determine how much weight the string held before it broke. Record the string length, string weight, and total weight the string held. Divide the weight of the string by the weight supported by the string to determine the strength weight ratio and compare the ratios for different types of fibers.

Paper Making

Required supplies for paper making include the following: shredded colored paper cut or torn into 2 inch pieces and soaked overnight in a dishpan of water, a blender, a pitcher, glitter, bits of paper, plant material to add to the paper slurry, a big plastic tub, a deckle (2 picture frames, window screen, staples and staple gun or a hammer and tacks), a sponge or wooden block, towels, dishpan, a piece of plywood, bricks, and white paper.

Fill a dishpan half full with warm water. Add pieces of cut or torn paper. You can use newspaper, construction paper, recycled office paper, or very small pieces of material. Allow the paper to soak at least 1 hour. Soaked paper can be frozen for later use. Fill a blender half full with water. Add one or two handfuls of soaked paper. Blend on high for several minutes to form a smooth mixture. If necessary, add more water. Place the deckle horizontally in a plastic tub with at least three inches of water. The deckle can be made from two 8 × 10 wooden picture frames. Remove the glass and back from each frame and staple or tack fine window screen to the back of one frame, covering the frame opening. Hold the frame with the screen face down in the water with the back of the other frame held tightly against the screen side. Add the paper mixture to the deckle. The sides of the picture frame will keep the mixture over the screen. Hold the deckle so it is partially submerged in the water and shake it gently to disperse the paper mixture evenly over the screen. To make paper more decorative and personalized add leaves, petals, glitter, etc. to the paper mixture and swirl to mix. Slowly lift the deckle from the water. Hold the deckle at a slight angle to allow the excess water to drain. Use a small wooden block or sponge to press some of the water out of the newly formed piece of paper. Remove the top frame from the deckle and flip the bottom frame with the paper onto a piece of white paper on a towel. Remove the frame from the wet paper and place another piece of white paper and towel on top of the paper. Blot the paper to remove as much excess water as possible. Remove the towels and transfer the wet paper to a thick stack of newspapers. Layer the newly made paper and newspapers, then place a large piece of plywood on the stack and a brick or heavy weight on top to squeeze out excess moisture.

Remove the newspaper after 24 hours and allow the pieces of paper to dry fully. The paper will be fairly thick, but can be used to make a cover for a notebook, a box, or as backing for thinner paper (Dawson, 1992; Grummer, 1990, Ramsay, 1999). Since the new paper is thick, it may warp as it dries; a steam iron can be used to smooth the paper.

DISCUSSION

We found this lab to be very successful. The lab proceeded smoothly if students were divided into the following three activity groups: dyes, fibers, and paper. Students completed one activity and then rotated to the next activity until all three were complete (see proposed lab handout).

There is a minimal investment in supplies and materials for developing this lab exercise, and many of the materials can be reused. The deckle and rope maker can be used for many years, and unused soaked paper can be frozen. The dyes can be stored in the refrigerator or freezer for long periods of time.

To help students summarize their dye experiment a chart can be made comparing the dye plant used with the color of the resulting dye and the color of the egg after it was placed in the dye. Some students may wish to use one dye color and leave their eggs in for varying amounts of time and compare the results.

When students make their rope have them indicate the fibers they used, then test the strength of the fibers and answer the following questions. What was the length of the string used? What was the weight of the string? How much weight did the string hold? What was the length:weight supported ratio? What was the weight of the string:weight supported ratio? What can the ratios above tell us about the strength of the string? When would it be better to use a synthetic rope? A natural rope? From what plant sources do different fibers such as hemp, jute, and manila come? Where do synthetic fibers come from? Do manufacturers ever mix natural and synthetic fibers?

After students make their paper ask them if they used any add-in materials to decorate the paper and what effect it had on their finished paper. What color(s) of pulp did they use? Did the colors of the pulp blend in to form one new color or does each color stand out? What is the overall consistency of their paper compared to notebook paper? How can this consistency be changed?

Students enjoyed performing this laboratory and learning about dyes, fibers, and paper. They were excited to make something (paper, colored eggs, rope) that they could take home. Art students especially appreciated papermaking. Students enjoyed decorating their paper by embedding glitter, leaves, or colored paper in their pieces of paper. This laboratory exercise could be employed in a biology or botany for non-majors course or in an ethnobotany course.

WORLD OF PLANTS LAB EXERCISE: DYES, FIBERS, AND PAPER

Exercise A. Natural Plant Dyes

Dye one egg, set it in the tray to dry, then fill in the information sheet by the tray. Before you leave lab today, fill in the chart below with information about the types of natural plant dyes you saw in lab and the color each produced.

Type of Dye	Color of Dye	Color of Dyed Egg
Coffee Seeds		
Yellow Onion Skins		
Blueberries		
Red Onion Skins		
Spinach Leaves		
Beet Root Juice		

Exercise B. Paper Making (Dr. Meekins)

Use the paper pulp and add-in materials available to make a piece of paper. Leave the paper in lab to be pressed and dried. Make sure to fill in the information sheet by the paper press and label your sheet of paper.

What color(s) of pulp did you use? _____

What add-ins, if any, did you add to the pulp? _____

Exercise C. Rope Making and Testing Fiber Strength

Make a piece of rope from the string provided. Fill in the information sheet by the rope making device to indicate the type of rope you made, then test the strength of the fibers in your rope and answer the questions below.

What fiber did you use to make your piece of rope? _____

What was the length of your string? _____ meters

What was the weight of your string? _____ grams

How much weight did your string hold? _____ kilograms

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